

## Supraventricular tachycardia with AV block

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*It is extremely difficult, even impossible – except in rare instances – to differentiate cases of paroxysmal atrial tachycardia with block from AV junctional tachycardia with forward block but free retrograde conduction to the atria. These cases are collectively termed supraventricular tachycardia with block. The arrhythmia is not uncommon and an incidence of 1 in 360 electrocardiograms was found in the last 6-year period.*

*Supraventricular tachycardia with block has a dynamic nature, and because it depends primarily on the electrocardiogram for its recognition a critical review of the salient cardiographic features is given. However, not uncommonly it needs to be differentiated from a long list of other disorders of the heart beat. The relation of the arrhythmia to other atrial disorders is discussed, and the presence of supraventricular tachycardia with latent block is mentioned.*

*Of the present series, 82 per cent were found to be precipitated by means that deplete body potassium in a digitalized patient suffering usually from an advanced cardiac disease. This group has a serious prognosis with 22 per cent mortality, but rapid intervention by discontinuing digitalis and diuretic measures and the administration of potassium and other antiarrhythmic drugs are usually effective. In 18 per cent of cases digitalis could not be blamed for the arrhythmia, and this group has a better prognosis, and digitalis may be beneficial in controlling the ventricular rate if heart failure is present.*

Though disorders of impulse formation and impulse conduction are usually treated separately in papers on the electrocardiogram they often show mutual dependence. Usually when a rhythm disturbance comprises both disorders the prognosis is less favourable. This is exemplified by cases of paroxysmal atrial tachycardia with AV block, long recognized as a serious complication of digitalis overdosage. Though the first description of a case was that of Lewis (1909), few cases had been described until 1943 when two large series were published by Barker *et al.* and Decherd, Herrmann, and Schwab. More recently, paroxysmal atrial tachycardia with block has become more frequently described, and its relation to digitalis overdosage was clarified by the extensive work of Lown and Levine (1958). However, much emphasis on the subject has obscured the fact that AV junctional tachycardia with or without block is an even more frequent manifestation of digitalis overdosage (Pick, Langendorf, and Katz, 1961; Soffer, 1961; Castellanos and Lemberg, 1963). At least 5 different types of AV junctional tachycardia with block have been described (Pick *et al.*, 1961); one of these is a case of AV

junctional tachycardia with forward conduction disturbance in the presence of a normal retrograde conduction to the atria. This type resembles cases of paroxysmal atrial tachycardia with block except perhaps for the direction of atrial activation, as judged by the inscription of inverted P waves in diaphragmatic surface leads. However, recently we have learned to depend less on the direction of the P wave as an indication of the site of impulse formation. Inverted P waves have been seen in experimentally induced low atrial extrasystoles and tachycardias (Prinzmetal *et al.*, 1952), while experimentally produced retrograde atrial activation may produce, against the rule, upright P waves in diaphragmatic surface leads (Moore *et al.*, 1967).

In the presence of a single ectopic supraventricular systole it may be possible to differentiate atrial from AV junctional origin, depending largely on the temporal relation between the P and QRS. The situation becomes more difficult in the presence of paroxysmal tachycardias initiated in the atria or AV junctional tissue. These are usually considered together under the term of paroxysmal supraventricular tachycardia, since their clinical manifestations and their response to exercise, carotid

sinus compression, and drugs are usually identical (Friedberg, 1966). It is now becoming extremely difficult, even impossible – except in a few instances as will be seen later – to differentiate cases of atrial tachycardia with AV block from cases of AV junctional tachycardia with forward block and normal retrograde conduction, simply because of loss of the fixed temporal relation between the P and QRS, while the direction of the P wave offers little help. The present work finds that such differentiation is in fact unwarranted, since the aetiology, clinical picture, salient electrocardiographic features, and management are practically the same. These cases can be collectively termed supraventricular tachycardia with complete atrial capture and forward AV block or simply supraventricular tachycardia with block. It should be emphasized here that other types of AV junctional tachycardia with block showing complete or incomplete AV dissociation, where the atria are basically controlled by the sinus rhythm or atrial fibrillation, are not included in the term, since these cases present sufficiently characteristic electrocardiographic patterns of their own.

#### Material and methods

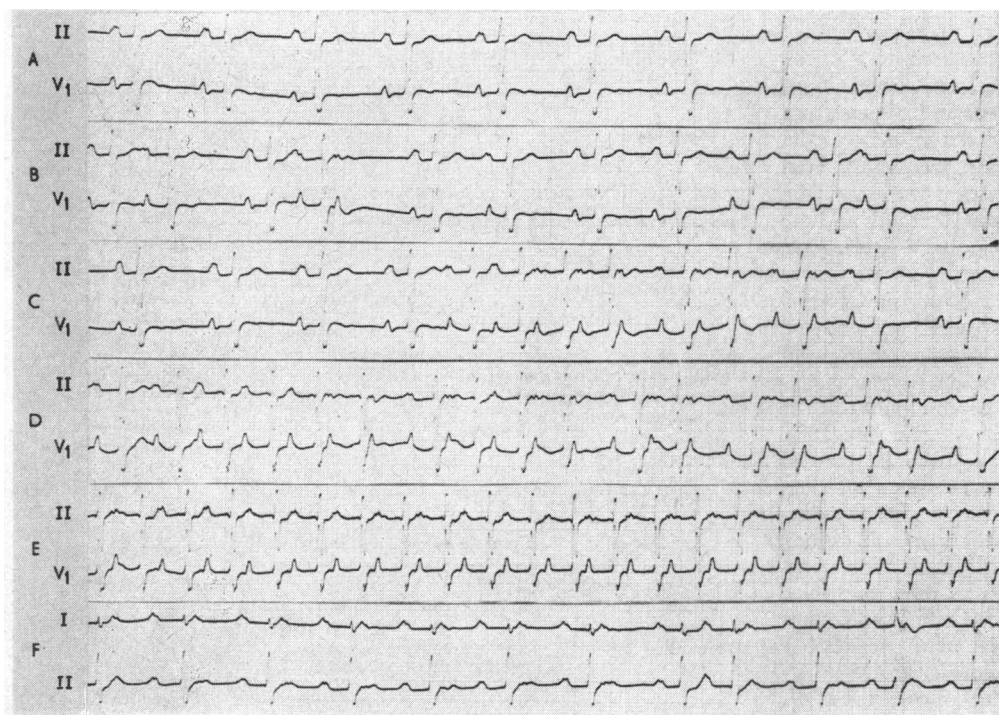
The electrocardiograms at Kasr El-Aini, Cairo University Hospitals, in the 6-year period from January 1962 to January 1968 were reviewed, and

records showing supraventricular tachycardia with block were studied. In a total of 23,500 electrocardiograms 66 cases were found. Most of them were studied and personally followed. In the few instances where personal contact was lacking, thorough review of the clinical and laboratory data was obtained. During the study, emphasis was placed on the type of heart disease present and details of the therapeutic measures employed, especially the digitalis and diuretic regimen. The onset and offset of the arrhythmia were recorded when possible. The course, duration, number of attacks, and measures instituted in the treatment were all included in the study. The electrocardiograms were analysed for atrial and ventricular rates, configuration of the atrial complexes, PP cycles, type of AV block, cardiographic manifestations of digitalis toxicity, and other associated rhythm disturbances.

#### Results

Pertinent data in the 66 cases that fulfilled the diagnosis of supraventricular tachycardia with block are summarized in Tables 1–3. The ages

**FIG. 1** *Supraventricular tachycardia with block showing varying degree of AV block. Note that the multiple ectopic P waves in record B arise from the same ectopic centre that later on discharges repeatedly. All records were obtained in one sitting.*



of the patients ranged widely from 18 to 75 years, with a mean of 38 years. More than half of them were in an advanced stage of congestive failure. Digitalis was regarded as the aetiological factor in the development of the arrhythmia in 82 per cent, using the criteria of Lown, Wyatt, and Levine (1960). Clinical signs of digitalis toxicity were usually lacking; however, electrocardiographic signs in the form of multifocal ventricular premature systoles, ST, and T changes were frequently recorded. Usually, these patients were on a maintenance dose of digitalis, and the arrhythmia developed after measures leading to excessive loss of body potassium, usually an intensive diuretic therapy.

During the period of observation 12 patients died, and all were cases of digitalis-induced supraventricular tachycardia with block. However, out of these only 4 patients had died in spite of active measures for treatment of the arrhythmia.

## Discussion

### Electrocardiographic features

**P Wave** There is a definite, yet sometimes slight, change in the contour of the P wave from the basic sinus P wave. This is particularly seen in records showing either the onset or offset of the arrhythmia (Fig. 1 and 2). The P waves were upright though sometimes diminutive in the diaphragmatic surface leads in 76 per cent and inverted in 24 per cent of the cases (Fig. 3). Though the contour of the P wave is in no way a sure sign of the site of origin of the ectopic discharge, it seems from this work that supraventricular tachycardia with block arises much more frequently from the upper part of the atria near the sino-atrial node than from the lower atrial region and the adjacent AV junctional tissue. As early as 1943, Barker *et al.* reported negative P waves in one-sixth of their cases of paroxysmal atrial tachycardia with block. Lown and Levine (1958) stated that the site of origin of the ectopic focus in paroxysmal atrial tachycardia with block was most commonly in the upper part of the atrium near the sino-atrial node. This criterion of positive P wave in diaphragmatic surface leads was, however, rigidly followed in later descriptions of tachycardia with block (Goldberg *et al.*, 1960), probably actively excluding cases with negative P waves on the basis of their presumed AV junctional origin. On the other hand, some authors included all cases with negative P waves under the heterogeneous group of AV junctional tachycardia with block (Pick *et al.*,

TABLE 1 *Aetiological diagnosis in 66 cases of supraventricular tachycardia with block*

Aetiology	No. of patients			
	Digitalis-induced arrhythmia		Arrhythmia unrelated to digitalis	
	Men	Women	Men	Women
Rheumatic heart disease	17	9	1	3
Hypertension	4	2	1	1
Coronary heart disease	7	1	4	—
Cor pulmonale	6	2	—	—
Cardiomyopathy	2	2	—	—
Atrial septal defect (post-operative)	—	—	1	1
Chronic renal failure	2	—	—	—
Total	38	16	7	5
	(54)		(12)	

TABLE 2 *Electrocardiographic characteristics in supraventricular tachycardia with block*

Rate/min.	< 100	101–120	121–150	151–200	201–250	> 250
Atrial	1	3	8	29	20	5
Ventricular	39	24	3	—	—	—
Type of AV block: 2:1			48			
Wenckebach			21			
complete			3			
varying			34			
Contour of P wave in diaphragmatic surface leads:						
positive (sometimes diminutive)				50		
negative				16		

TABLE 3 *Therapeutic considerations in supraventricular tachycardia with block*

Therapeutic measure	No. of cases	No. of successful reversions
<i>Digitalis-induced arrhythmia</i>		
potassium by mouth	10	8
potassium intravenously	18	17
procainamide	6	5
antazoline	2	2
phenytoin	2	2
propranolol	4	4
Total	42	38
<i>Arrhythmias unrelated to digitalis</i>		
procainamide	4	4
propranolol	2	2
digitalis	6	4
Total	12	10

1961; Castellanos and Lemberg, 1963). As already mentioned, the contour of the P wave is not a sure sign of the site of origin of the ectopic discharge. A positive P wave may arise from retrograde activation of the atria and a negative P wave may arise not in the AV junctional tissue but in the lower part of the atria. It is only in one condition that we become reasonably sure that the negative P wave arises from AV junctional tissue; this is seen in Fig. 4 which shows an ectopic centre of discharge with an intrinsic rate of 200 beats a minute that sometimes shows 2:1 exit block. When the centre discharges freely at a rate of 200, there is a 2:1 AV block, and we are faced with a supraventricular tachycardia with block where it is impossible to tell whether the site of origin is in the lower atrial or AV junctional regions. However, when a 2:1 exit block develops we get an arrhythmia similar to what has been termed 'non-paroxysmal nodal tachycardia' by Pick and Dominguez (1957). Here the AV junctional origin could be suggested depending on the temporal relation of the P following the QRS. In fact, exit block of an AV junctional ectopic centre, as shown here, is rare. We have found only 3 reported cases of a similar condition, where exit block was shown in cases of paroxysmal atrial tachycardia (Calviño, Azan, and Castellanos, 1957; Phibbs, 1963; Dressler, Jonas, and Javier, 1966). Cases of AV junctional arrhythmia described as showing exit block (Pick *et al.*, 1961; Castellanos and Lemberg, 1963; Pick and Langendorf, 1968) are in fact wrongly named. All these cases are associated with atrial fibrillation, and usually a complete block exists between the fibrillating atria and the AV junctional centre, while what is called an exit block represents simply a form of forward block of a varying degree and does not deserve the term of exit block as classically understood.

**Atrial rate** The rate of discharge of the ectopic pacemaker in supraventricular tachycardia with block shows a wide range. The highest rate recorded in this series was 295 beats a minute and the lowest rate in which the ectopic centre was still dominant was 72 (Fig. 5). This is quite a slow rate for an ectopic atrial focus, and can only be explained by assuming a certain degree of depression of the sino-atrial node. Rates as high as 400 (Simonson and Berman, 1951) and as low as 106 (Lown *et al.*, 1960) have been reported. However, in 86 per cent of the present series the atrial rate ranged between 120–250. It appears that there is a significant overlap between supraventricular tachycardia with block and

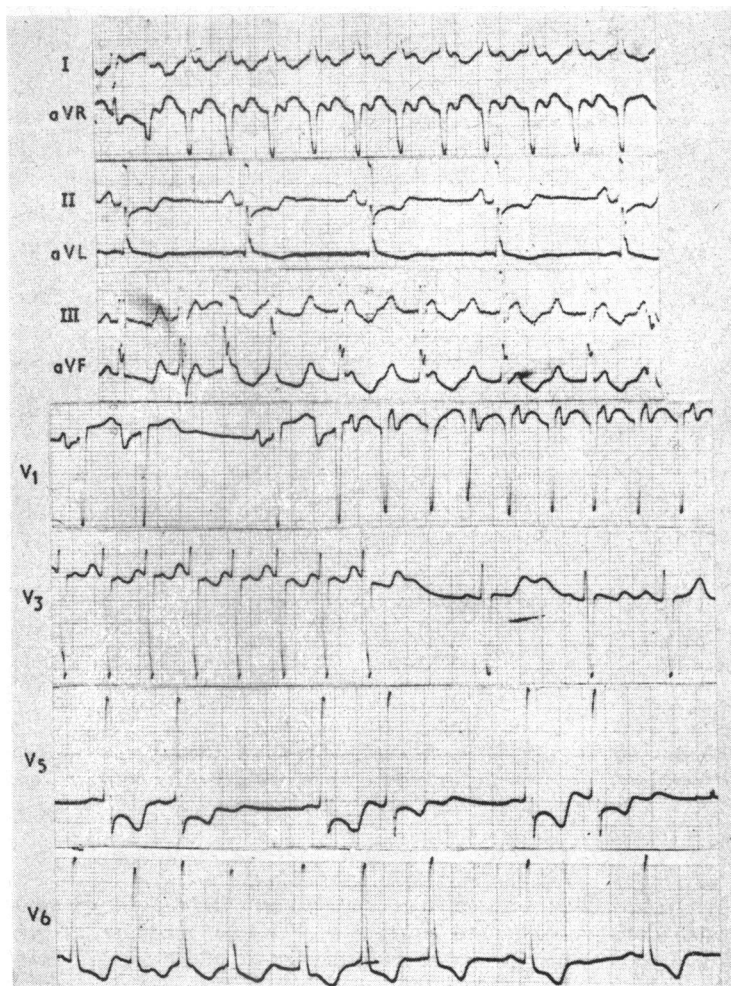


FIG. 2 The dynamic nature of the arrhythmia was fully shown during the routine recording of the electrocardiogram by a technician. The whole procedure usually took 3–4 minutes during which several short paroxysms of supraventricular tachycardia with varying degree of AV block were recorded, sometimes initiated by a premature atrial systole (V1).

atrial flutter at the high rate levels, and between it and sinus tachycardia or even normal sinus rhythm at the low rate levels; this makes it hazardous to depend solely on the atrial rate for their differentiation.

**PP interval** In one-third of our cases the PP cycles varied in their duration, the variation ranging from 0.01 to 0.22 of a second (Fig. 6 and 7B). Half of the cases of Lown *et al.* (1960) showed variations of up to 0.12

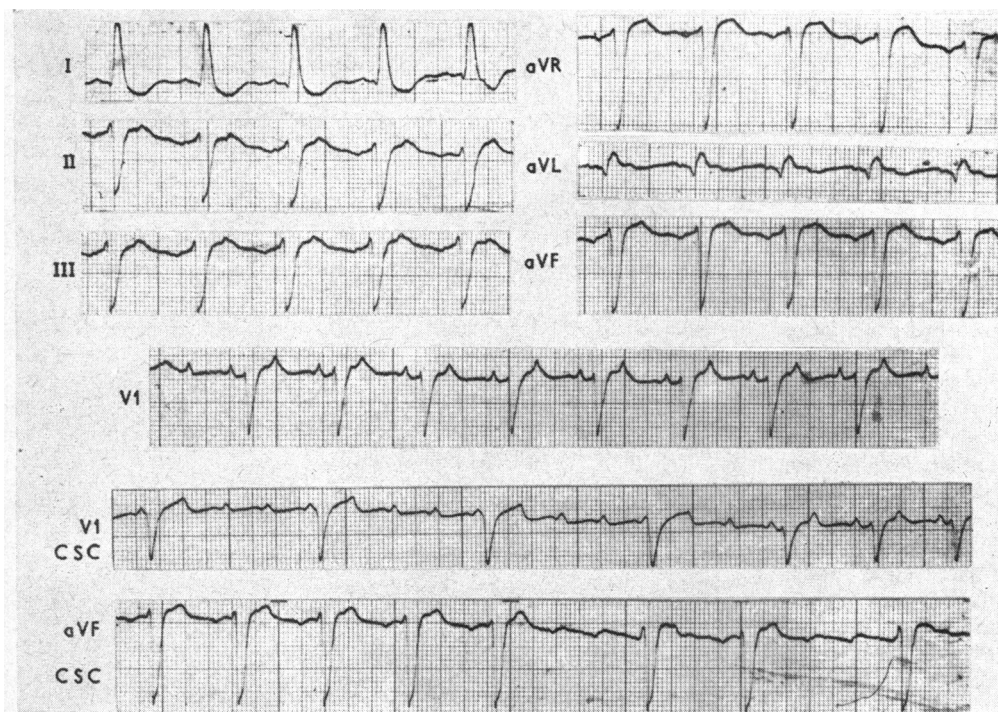


FIG. 3 Supraventricular tachycardia with block showing inverted P waves in diaphragmatic surface leads. The blocked P waves are barely discernible; however, carotid sinus compression (CSC) gives rise to an increased degree of AV block and the atrial mechanism can easily be shown.

of a second. This phenomenon has various explanations: a commonly acceptable view is the negative chronotropic effect of the ventricular systole (Rosenbaum and Lipeschkin, 1955). Classical paroxysmal supraventricular tachycardia and atrial flutter, on the other hand, are characterized by a regular PP cycle length.

**PP baseline** An isoelectric baseline of 0.04 sec. or more in every lead including the oesophageal leads is considered a *sine qua non* in supraventricular tachycardia with block, while atrial flutter is characterized by an undulating baseline in one or more leads. Prinzmetal *et al.* (1951) suggested that the undulating appearance of atrial flutter was due to the combination of ectopic P waves and the oppositely directed  $T_a$  waves. The more rapid the atrial rate, the larger the  $T_a$  wave. Rosner (1964) suggested that it was possible for paroxysmal atrial tachycardia with block associated with very fast atrial rates to show continuous baseline activity as a result of atrial repolarization becoming electrically more prominent. Kennamer and Prinzmetal (1954) have denied that the differentiation between paroxysmal atrial

tachycardia with block and atrial flutter can be made by the presence of isoelectric intervals between P waves. On the other hand, Lown *et al.* (1960) think that paroxysmal atrial tachycardia with block and slow flutter usually retains the PP baseline characteristics. In our experience it is only the second half of this view that holds true. While it is practically always possible in the presence of atrial rates below 200 to differentiate supraventricular tachycardia with block from atrial flutter, it is quite possible that above this rate – and especially above 250 beats a minute – the decision concerning the presence or absence of an isoelectric interval may be difficult to make. There is always the subject of inter-individual and intraindividual variations in interpretation (Prinzmetal *et al.*, 1952; Epstein *et al.*, 1961; Caceres, 1963).

**AV response** All types of AV block from first degree to complete were recorded, and in many cases there was a shift from one type to another (Fig. 1 and 2). The predominant type of AV heart block was, however, second degree AV block, frequently as sustained 2:1 block with the sporadic Wenckebach's phe-

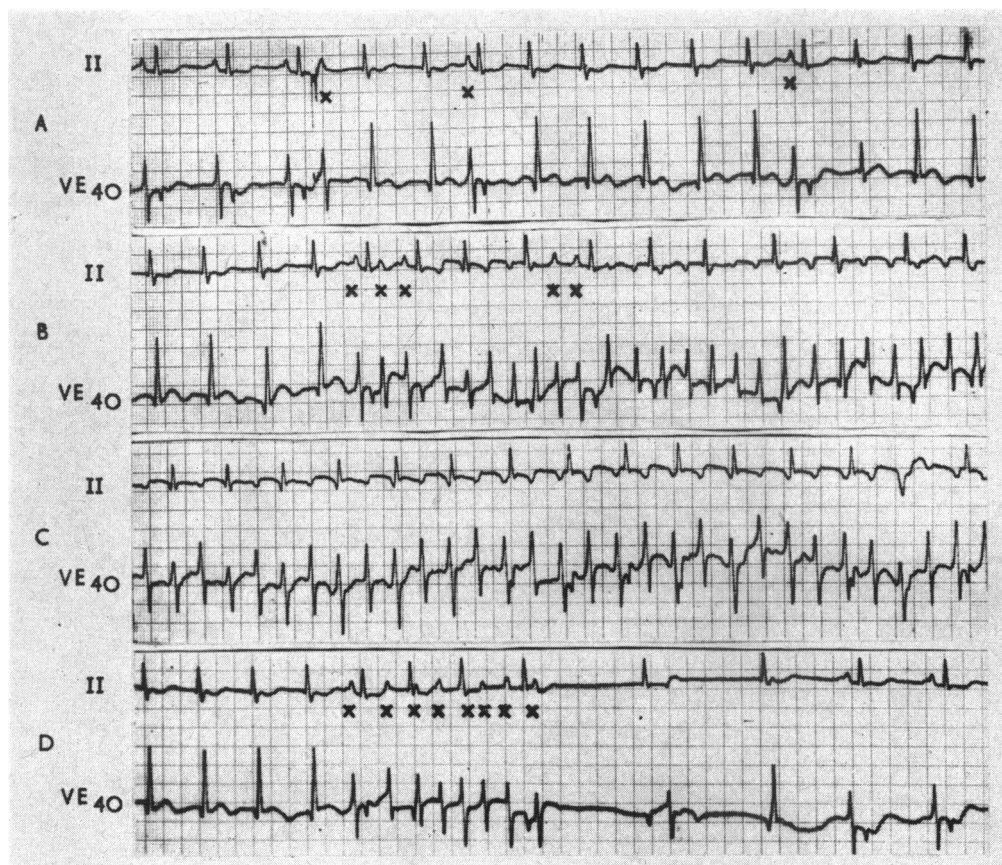


FIG. 4 Supraventricular tachycardia with exit block and double supraventricular tachycardias. Record A shows the development of AV junctional tachycardia with inverted P waves in lead II after the QRS complexes simulating terminal S waves. Record B shows the release of a 2:1 exit block giving rise to a supraventricular tachycardia with AV block; this is continued in record C. Record D shows a short paroxysm of tachycardia from the same atrial focus giving premature atrial systoles marked X above.

nomenon. Vagal stimulation and carotid sinus compression usually increase the degree of AV block but have no effect on the atrial rate (Fig. 3 and 8). In a few instances pseudo-bigeminy was shown (Fig. 8). This uncommon type of AV conduction was originally described in atrial flutter (Basoain-Santander, Pick, and Langendorf, 1950) but was not previously reported in supraventricular tachycardia with block. It is explained by the presence of two levels of block in the AV junctional tissue, a 2:1 conduction ratio in the upper region of the AV junction, and a 3:2 conduction ratio in the lower region.

#### Supraventricular tachycardia with block and other atrial arrhythmias

The relation between supraventricular tachycardia with block and atrial flutter has been

mentioned during the discussion of the PP baseline characteristics. Four patients in the present series have shown an increase in the rate of discharge of the ectopic supraventricular focus, with loss of the isoelectric baseline characteristics, either shortly after successful therapeutic reversion of supraventricular tachycardia with block (Fig. 7c) or in the wake of increase of the digitalis dosage and intensive diuretic therapy (Fig. 5). Whether these cases represent instances of rapid supraventricular tachycardia with block or atrial flutter is difficult to tell. Rosner (1964) called those cases, consisting primarily of rapid atrial activity but without any special appearance of the baseline or atrial wave form, 'atrial tachysystole with block', and this has been taken to favour the view that there is a continuum between supraventricular tachycardia and

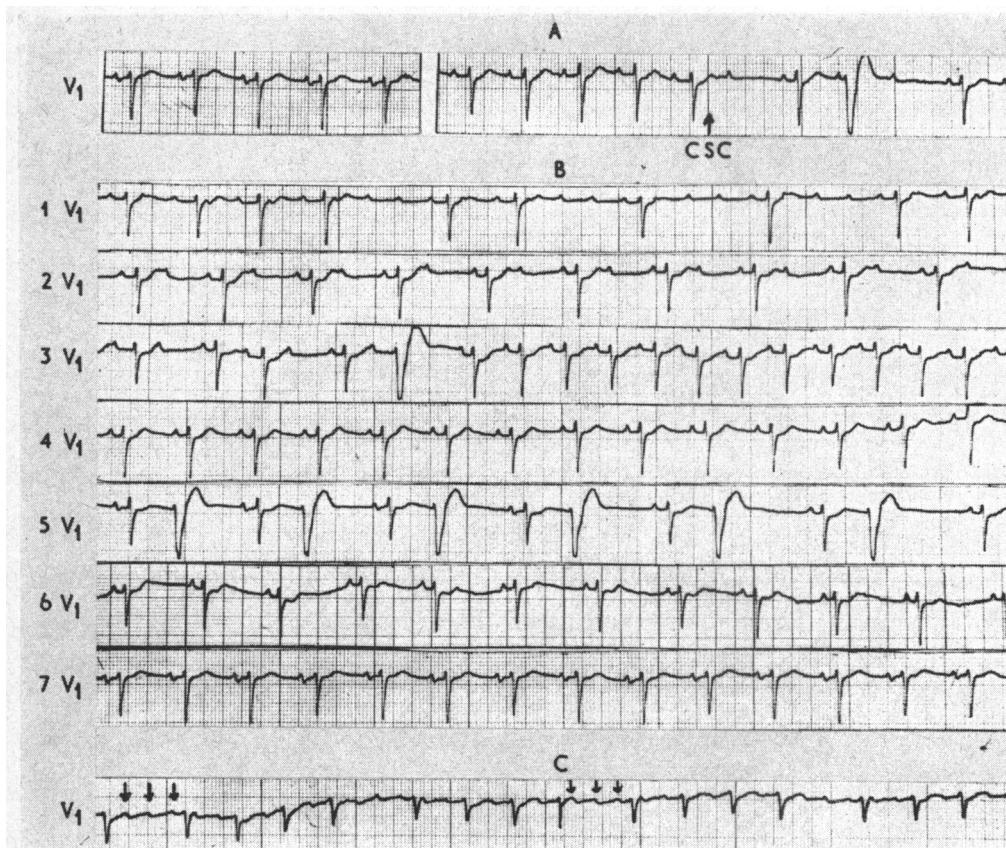


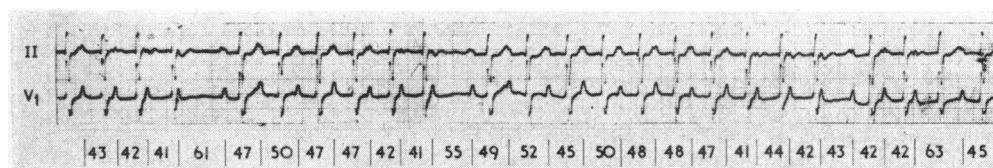
FIG. 5 Record A shows supraventricular tachycardia with latent block in the second strip. The records under B show supraventricular tachycardia with AV block and the sequences of potassium infusion. Note that the sinus rhythm began to show in the first half of record 5 at a rate which is higher than that of the ectopic centre in the second half of the record. The ectopic centre was still dominant at a rate of 72 a minute (record 6). Record C was obtained shortly before the death of the patient, who was again under digitalis; it shows an atrial rate of 250 a minute and no PP isoelectric intervals.

atrial flutter, with an intermediate zone that defies exact differentiation. The present work cannot prove or disprove this view. However, we think that in these cases the establishment of the role played by digitalis in the pathogenesis of the arrhythmia will have a greater repercussion on both prognosis and management than the still biased theoretical discussion. It is pertinent to mention here that

digitalis-induced atrial flutter is a rarity (Delman and Stein, 1964).

The mechanism preceding the onset of supraventricular tachycardia with block was generally normal sinus rhythm. However, in 5 cases the arrhythmia developed on top of established atrial fibrillation. Though Lown *et al.* (1960) mentioned that a sinus mechanism was restored irrespective of the antecedent

FIG. 6 Supraventricular tachycardia with block showing variable PP cycle lengths.



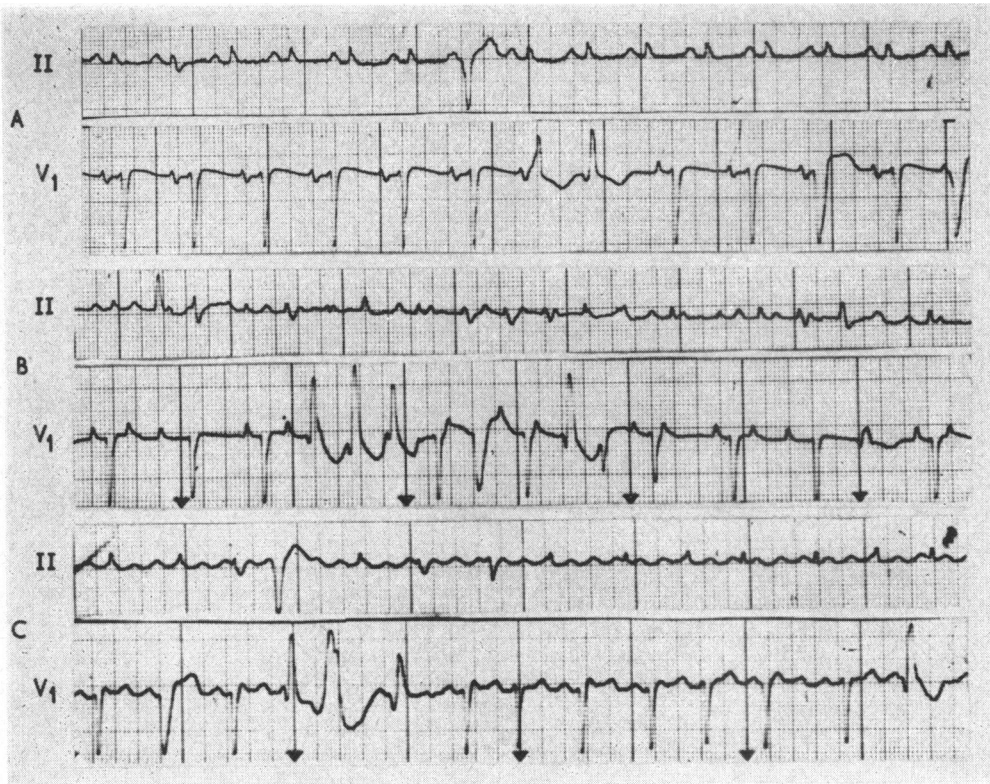
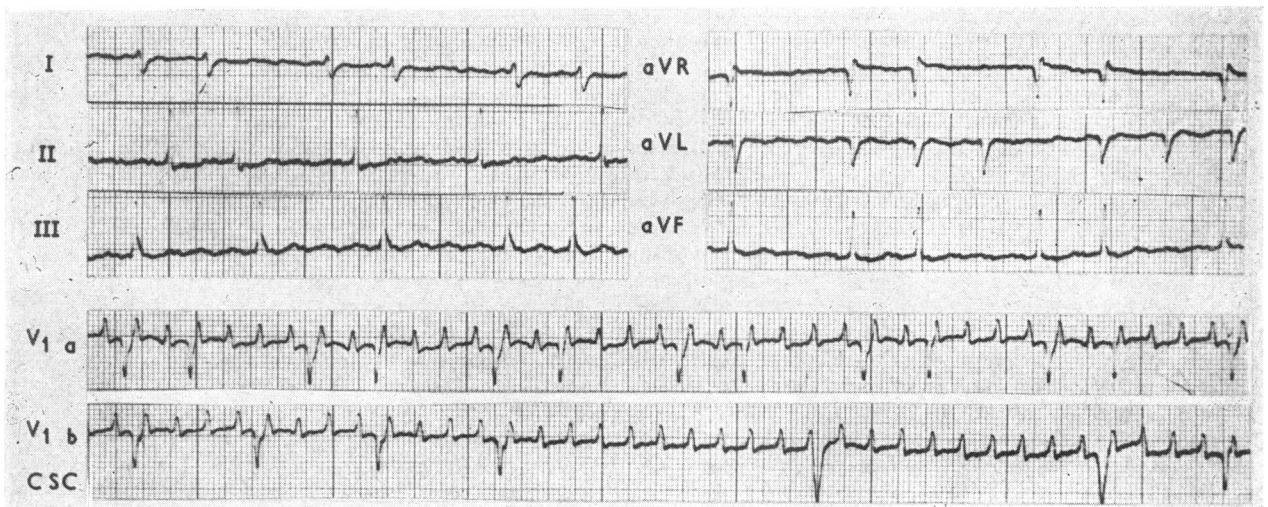


FIG. 7 Supraventricular tachycardia with block and atrial flutter. Record A taken on admission showed sinus rhythm and multifocal ventricular premature systoles. Record B obtained 4 days later when the patient was fully digitalized showed supraventricular tachycardia with block and varying PP cycle lengths. The ventricular premature systoles had increased in number. Withholding digitalis and the administration of oral potassium restored the sinus rhythm promptly; however, record C obtained 2 days later showed classical atrial flutter.

FIG. 8 Supraventricular tachycardia showing two levels of AV block. V1a shows a form of pseudobigeminy where the long RR cycles are not double the short RR cycles. This could be explained by assuming the presence of 2 levels of block in the AV junctional tissue.



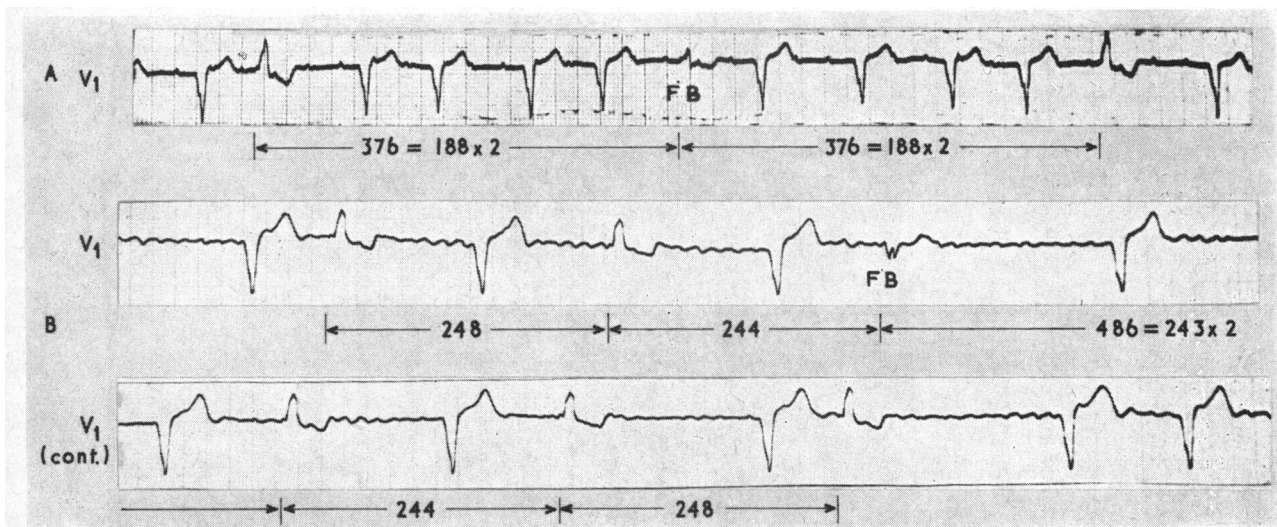


FIG. 9 Supraventricular tachycardia with block on top of chronic atrial fibrillation. Record A shows the development of supraventricular tachycardia with block in a patient known to have chronic atrial fibrillation. Withholding digitalis and the administration of propranolol resulted in re-establishment of atrial fibrillation (record B). It is interesting to observe that propranolol failed to abolish the ventricular parasystolic focus present but slowed down its intrinsic rhythm. FB represents fusion beats.

rhythm, this was not our experience where re-establishment of atrial fibrillation was noticed after control of the arrhythmia (Fig. 9). It is to be stressed here that when supraventricular tachycardia with block develops on top of atrial fibrillation, the atria stop fibrillating and begin to contract rhythmically in response to the ectopic focus. This differs from the admittedly more frequent manifestation of digitalis toxicity where enhancement of an AV junctional pacemaker develops while an area of block between the fibrillating atria and the ectopic centre is present.

The occurrence of 2 supraventricular pacemakers competing for the atria was occasionally observed as a transient phenomenon during the evolution of the arrhythmia (Fig. 4). Usually one of the pacemakers is ill sustained, and this may explain why this phenomenon of 2 supraventricular pacemakers both capturing the atria was rarely recorded (Chung and Thomas, 1965). This differs from the more frequent situation of double AV junctional pacemakers, the upper one capturing the atria while the lower one controls the ventricles, producing a complete or incomplete atrioventricular dissociation (Pick *et al.*, 1961; Castellanos and Lemberg, 1963).

Lastly, the presence of a supraventricular tachycardia with latent AV block was rarely mentioned. This arrhythmia is characterized

by an increase in atrial rate with an alteration in P wave contour, and differs from supraventricular tachycardia with overt block in that the PP interval is normal and that AV block is induced only by carotid sinus compression (Bernstein and Stanzler, 1966) and/or digitalization. This arrhythmia was originally described by Lown and Levine (1958) as a stage during the evolution and recession of paroxysmal atrial tachycardia with block. However, this period as described by Lown and Levine (1958) was brief, which could be explained by the rapid nature of the experiments undertaken (Bernstein and Stanzler, 1966). It is possible for this stage to be prolonged if there is a gradual digitalis overdose or potassium depletion. One of these patients was noticed by Lown and Levine (1958), and 2 more cases were later described (Bernstein and Stanzler, 1966). One of our cases helped to show classically this type of arrhythmia (Fig. 5). This was a case of coronary heart disease receiving combined digitalis and diuretic therapy for congestive failure, but the heart rate failed to slow down. An electrocardiogram recorded one week after admission showed an atrial rate of 105 a minute and a change in the contour of the P wave which was difficult to explain. A trial to slow down the heart rate by carotid sinus compression gave rise to AV block with little

effect on the atrial rate. The significance of these changes was not grasped at that time, and more digitalis was given. However, clinical irregularity was observed in the pulse and an electrocardiogram 10 days later showed supraventricular tachycardia with AV block and an atrial rate of 190 a minute. The contour of the P waves was the same as that observed in the previous record which was now correctly interpreted as showing supraventricular tachycardia with latent block. When digitalis was stopped and K infusion started the atrial rate regressed and sinus rhythm was established. It was interesting to observe that the ectopic centre remained dominant at an atrial rate of 72/min.

Apparently these cases are relatively rare; however, recognition of their occasional relation to a lesser degree of digitalis toxicity is important so that the more serious consequences of further digitalis administration or of potassium loss can be avoided.

### Diagnosis

As a rule, the diagnosis of supraventricular tachycardia with block depends essentially on the electrocardiogram, but even the tracing is sometimes missed or confused with other arrhythmias. This is probably the result of the dynamic nature of the arrhythmia, and hence the varying phases that it may assume in its development or recession. The main difficulty will arise from failure of recognition of the atrial activity either because these are diminutive in the conventional leads taken or because of superimposition of some or all of atrial waves on the QRS-T complexes. This difficulty will be accentuated in the presence of a varying degree of AV block. Sinus rhythm, sinus tachycardia, paroxysmal supraventricular tachycardia, atrial flutter, atrial fibrillation, and ventricular tachycardia may enter into the differential diagnosis at one time or another.

Though the use of carotid sinus compression or right chest leads is sometimes highly effective in the diagnosis by clarifying the atrial mechanism, the best way of unravelling the atrial activity is by the oesophageal electrode (El Sherif, El-Ramli, and Sorour, 1969), (Fig. 4).

No essential electrocardiographic differences were found between cases of digitalis-induced supraventricular tachycardia with block and those unrelated to digitalis. This contrasts with previous claims (Oram, Resnekov, and Davies, 1960).

### Prognosis

The prognosis in digitalis-induced paroxysmal atrial tachycardia with block was considered serious. The reported mortality rate varied from 28 per cent (Freiermuth and Jick, 1958) to 58 per cent (Nadas, Rudolph, and Reinhold, 1953). This is undoubtedly related to the underlying serious heart disease (Lown *et al.*, 1960). It seems unlikely that the arrhythmia itself is directly detrimental to the cardiac function and cardiac output (Goldberg *et al.*, 1960). In the present series the mortality in the digitalis-induced supraventricular tachycardia with block was relatively high (22%). However, most of the cases died either because the arrhythmia was not suspected, and therefore no specific management was undertaken, or because it was misdiagnosed, usually as atrial flutter, and digitalis was continued. Therefore, out of 42 cases of the digitalis-induced arrhythmia receiving specific treatment, only 4 died during the period of observation (9%). On the other hand, the prognosis was excellent in the minor group unrelated to digitalis, with no single fatality during the observation period.

### Therapy

When the arrhythmia is due to digitalis, withholding the drug may suffice by itself, but frequently a potassium-losing state is present and potassium has to be given. There are in general two main routes for severe potassium depletion, namely intestinal and renal, of which the renal loss through the indiscriminate use of diuretics is the most important. But even potassium loss through haemodialysis has sometimes been implicated (Lown *et al.*, 1953). Either the oral or intravenous routes may be chosen. Usually the atrial rate shows gradual slowing before reversion to sinus rhythm and sometimes 1:1 conduction, with paradoxical increase of the ventricular rate (Fig. 5). If potassium is contraindicated or ineffective, other antiarrhythmic drugs can be used. Procainamide, antazoline, phenytoin, and propranolol have all been tried with success in the present series (Table 3). A case report of the successful use of DC shock after failure of other measures was given by Corwin, Klein, and Friedberg (1963).

On the other hand, when the arrhythmia is unrelated to digitalis the various antiarrhythmic drugs can be tried. More important is the fact that digitalis can be successfully used. The aim of digitalization is usually the control of heart failure and/or the rapid ventricular rate. Digitalis was given to 6 patients in the present series, and in all of them it suc-

cessfully controlled the failure and slowed the ventricular response. The arrhythmia was seen to disappear after the control of failure in 4 of them while they were still under digitalis. The beneficial role of digitalis in paroxysmal atrial tachycardia with block not induced by digitalis was observed as early as 1943 by Barker *et al.*, and was later stressed by Morgan and Breneman (1962).

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